

ICT: GENERAL ECONOMIC APPROACH

The market, the behaviour, the benefits

Synopsis. The introduction of Information and Communication Technology created a number of new commodities that, in addition to traditional fixed telephone, had a significant impact on economic activity and affected either the production process and the expressed demand in the market.

The paper outlines the Provider's strategies in the attempt of giving a basic description of the economic activity. The wide range of commodities offered to the market is, as well, changing the demand behaviour: for Business Sector, Digital Communication became a significant working tool which seems to have provided the benefit of improving Labour efficiency. Relevant cost to pay is compensated through the selling price of good/service produced.

On the other side, Residential sector makes, still, significant recourse to traditional telephone services but there are, more and more, groups of users that ask for the new available services. Such kind of consumers have to constrained their demand as they rely exclusively on their income.

The paper suggests some basic models to help describe the processes of production and of the demand. Reference is made to indicators available internationally (ITU, World Bank) which may provide sufficient details when analysing the economic game between supply and consumption.

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1. The market structure

After 1995 (deregulation), and during the last 10 years, the implementation of new technology gradually changed the communication sector; together with the traditional fixed telephone which lets transmission of voice and fax, the new network based on optical fibres, satellite and cables gradually promoted the expansion of mobile telephone, the access to Internet and to the services provided. From all fixed/mobile points it is, to day, possible to send messages, voice, images and to exchange documents, information and data. The introduction of broadband already opened the access to more complex commodities (images, TV); at world level, national authorities have already planned to expand the digital network as to serve their whole

country. The task is not always easy, depending from the coverage of territory, the existing communication plans, the financial resources available and, above all, from the users' consciousness of service benefit and from the national economic situation (economic return).

The new range of services involves the interest of both Firms and individuals: in the first case, the new commodities are used to improve the efficiency/productivity of working activity and, in the second case, to satisfy personal and final needs.

To day, under competitive supply of services/commodities, Providers face a market where there is no longer a stable revealed preference but rather a continuous moving of users from one to another competitor, from one to another commodity and from one to another device made available by suppliers. It is difficult, under such a scenario, to make consistent charging plans since tariffs are no longer linked with relevant unit cost incurred; rather, Providers are obliged to develop strategies to attract users and to secure their market quotas.

2. The expansion of commodities

From available ITU statistics (1991-2004) it was possible to follow the implementation over time of four commodities: fixed telephone, mobile telephone, PC and Internet. **Graph 1**, in the **Annex 2.1**, shows the different growth of the services under analysis.

In particular, fixed telephone users increased regularly from 1991 to 2001; at this year previous trend reduced. In the same period mobile telephone accelerated its increasing. As the two services are natural substitutes, a correlation was studied between the two commodities to check possible inter-relationship. **Graph 2**, in the same Annex, proves that a correlation between the two variables exists and that it is strong ($R^2 = 0,999$). During the period analysed and, possibly, for few years ahead, the polynomial function that describes the relationship can be successfully used.

Still from the Table in **Annex 2.1**, it seems that no relationship might exist between the expansion of PC and the users' access to Internet. But the two curves come, like mobile and fixed telephone functions, to cross each other in 2002, after which Internet was increasing faster than PC. Given that PC was necessary to access Internet, PC and Internet were complement and must be used jointly to access the service. The correlation between PC (as independent variable) and Internet (dependent variable) is significant (R^2 is close to 1) then the polynomial function which represents the relationship between the two variable is valid. Further data in the next years may confirm or not the correlation function: to day access to Internet is provided even via mobile telephone so that the relationship between the two variables may, possibly, modify.

A third analysis would have been interesting by studying a multiple correlation among Internet users (as dependent variable) and fixed telephone, mobile telephone and PC as independent variables. The study should have been interesting as it would let specify better a new attitude of the market, but for significant results it is, maybe, prudent to wait for additional statistics.

3. The production function

From a very general point of view, the process developed by a Telecommunication Firm, when carrying up its business, may be seen as dependent by two main activities: a technical

one and an operating one. The technical activity concerns the expansion of plant: when new lines (X_1) are added to the existing network, the infrastructure of the system is adapted to handle the new expected consumption. The number of lines (X_1) is assumed as the variable proportionate to capital expenses and describes the implementation of plant over time.

The personnel, engaged in a Telecommunication Firm, cover many functions which are directly (planning, maintenance i.e.) and indirectly (marketing, accounting, management) concerned with the expansion of plant. The number of employees (X_2) is assumed as the reference indicator for this activity in the production process.

By no mean labour (X_2) can replace the physical network installed (X_1) Because of that, the variable X_2 must be considered as a complement to X_1 rather than a substitute..

4. The production function: a possible model

Whether the above scheme of productive process is accepted, the production process may be represented in implicit form:

:

$$F = f(Q_1, \dots, Q_n, X_1, X_2)$$

Where “ Q_i ” are the quantities of commodities produced and “ X_1 (capital)” , “ X_2 (personnel)” are the input resources as specified in previous paragraph.

Provisional profit (before taxes and other financial engagements) is the balance between total revenue from the sale of all commodities and the expenditure (capital + labour) for all inputs, over the same period:

$$P = \sum_n p_i Q_i - \sum_2 R_i X_i$$

where p_i are the prices of commodities and R_i are the costs of X_i .

Maximisation of profit, subject to the constraint given by the production function “F”, is given by considering the following function:

$$S = \sum_n p_i Q_i - \sum_2 R_i X_i + \lambda * f(Q_1, \dots, Q_n, X_1, X_2)$$

Its solutions are derived by the set of partial derivatives (Q_i, X_i, λ) equal to zero. Only as an example, one of the possible conclusions that can be drawn is that, in particular, for every pair of outputs (holding the levels of all other outputs and inputs constant) the Provider may decide to reduce “ Q_i ” and to increase “ Q_k ” as a function of their ongoing inverse price ratio and this conclusion is valid for any couple of services.

The growth of telecommunication business depends upon harmonic growth of labour, of capital invested and of revenue. The optimum would be when the three rates were equal and the system would be perfectly balanced: whether, in fact, no external factor affects the system, the productivity of labour and the ratio revenue/capital would be constant over time. Under these conditions, neither the capital investment would increase faster than output (excess capacity provided) nor the market demand would be unsatisfied (shortage of capacity).

5. The production function: apportioning input variables

Under the present Market Competition situation, it is difficult to get reliable and detailed statistics that let separate capital and labour expenses. To provide, anyway, a rough idea on how the two variables are apportioned, the Salaries and the GDP have been taken as basic information. Under the hypothesis that GDP includes only investment and salaries, the ratio between Salaries and GDP gives, in percentage, the quantity of labour used in the production process. The prudence in accepting such a final results comes from the fact that neither Salaries, by themselves, represent total operating expenses relevant to labour resources nor GDP includes more than simple Communication investment.

Final figures are given in **Annex 2.2** for the period 2001-2006.

From the **Annex 2.2**, which provides details by World Region, it appears that in the Regions Europe, and Africa/Middle East the expenses dedicated to Labour decreased over time: by 2006 labour expenses represented, over total production expenses, 39,14% for Europe (–2,68% per year over the period) and 36,44% for Africa/Middle East. (–3,93% per year over the period). North America and Latin America almost kept, over the period, the same ratio between capital and labour expenses: at the year 2006, North America show 47,03% for Labour expenses (48,24% in 2001) while Latin America has 41,32% of Labour expenses (41,18% in 2001). The only Region that show an increase in labour expenses is Asia/Pacific: it moved from 46,81% in 2001 up to 50,17% in 2006.

The apportionment of the two input variables (X_1 ; X_2) can be derived from the study of the function given at paragraph 4 used for maximising profit. To this extent, it is important to remark that the apportionment of labour is neither a pure nor an easy mathematical choice. Personnel has to cover different sectors in technical and administrative Provider's structure and is engaged to work under current production methods. But when technological progress (greater capacity per line, digital transmission systems, improvement of operating procedures) lets increase revenue without requiring proportionate increase in labour, then existing number of employees may turn redundant and must be re-oriented or fired.

Some reduction of personnel took place as a logical consequence of liberalisation of Communication service (1995): under competitive regulation, Firms aimed to reduce personnel because of its cost and tried, instead, to increase its efficiency.

6. The provider: intermediate consumption

As intermediate consumption it is usually intended the expense necessary to support the working processes (telephone, messages, office material, intranet, etc). Here the tentative was made to possibly measure the impact that ICT has over the total expenses of Firms in a country. Unfortunately, the only statistics available with the necessary details were revenue for fixed and mobile telephone; it was not possible to access detailed statistic on internet, computers, TV and other commodities. The indicator included in the following table refers only to fixed and mobile telephones; it was obtained by calculating the average revenue per line and,

then, dividing it by the average GDP/employee. Under such working hypothesis the results are the followings (**Annex 2.3**).

REGIONS	2002	2003	2004	2005
Europe	12,93%	12,40%	11,36%	10,17%
North America	8,54%	8,05%	6,74%	5,39%
Asia/Pacific	8,97%	7,31%	6,06%	5,00%
Latin America	2,92%	3,04%	2,54%	1,94%
Africa/Mid East	8,87%	8,00%	6,31%	5,36%

The use of telephone (fixed and mobile) by average Provider, per Region, ranges in 2002 from 3% (Latin America) up to 13% (Europe); a significant information offered by the table is that the intermediate consumption seems to decrease over time and all over. This at least confirms that the use of fixed and mobile telephones do not increase as in the past since new and, possibly, more interesting commodities are offered, including voice transmission.

7. The Provider: the productivity of Labour

The productivity of a variable (capital, labour) is defined as the quantity of revenue that the variable can provide: a first approach to measure the productivity of a variable is the ratio between total revenue and the value of variable (*gross productivity*). The indicator, nevertheless, does not account for the fact that an input resource can produce output only when it is used jointly with other resources. A better approach is, then, given by the ratio between revenue, assigned to a variable (capital, labour), and the value of that factor (*net productivity*).

Given the difficulty of separating revenue as a function of a single variable, it is assumed, for sake of simplification, that it is legitimate to regard labour as the only factor producing revenue. In this way the difference between total revenue and capital expenses is assumed as the net revenue attributable to labour.

Again, under present situation, it is difficult to get statistics sufficiently detailed as to carry on the estimate of productivity of labour. The indicator wanted is the ratio between Revenue of Communication Sector by Salaries paid to employees engaged in the Sector. But no useful detail exists as to estimate the terms of the ratio; consequently an alternative approach was used. In particular the ratio between GDP and Salaries was adopted under the assumption that GDP is proportionate to the amount of expenses to recover. The final figures obtained represent the minimum ratio to salaries that revenue should have to, at least, balance total production expenses.

The exercise is given in **Annex 2.4** and is summarised in the following.

The Region Europe & Central Asia

At the year 2001, the ratio between GDP and salaries was 2,230. That is: revenue should be 2,230 times the salaries paid to Communication Sector to balance the production expenses. It

is, then, the minimum return a Provider should earn to survive; any value of the ratio greater than 2,230 will produce profit.

At the year 2006, the basic ratio moves up to 2,555, having moved up and down during the period. The minimum productivity requested by the system is greater than in 2001; the charging strategies should produce revenue that not only satisfy basically this objective but should be greater.

The Region North America

At the year 2001, the ratio between GDP and salaries was 2,073. That is: revenue should be 2,073 times the salaries paid to Communication Sector to balance the production expenses. It is, then, the minimum return a Provider should earn.; to produce profit the value of the ratio should have been greater than 2,073.

At the year 2006, the basic ratio moves up to 2,126, moving to greater values during the period. The minimum productivity requested by the system is, anyway, greater than in 2001; the charging strategies should produce revenue greater than the basic objective.

The Region East Asia & Pacific

At the year 2001, the ratio between GDP and salaries was 2,136. That is: revenue should be 2,136 times the salaries paid to Communication Sector to balance the production expenses. It is, then, the minimum return a Provider should earn to survive; any value of the ratio greater than 2,136 will produce profit.

At the year 2006, the basic ratio moved down to 1,993, having taken greater values during the period. The minimum productivity requested by the system is lower than in 2001; in this case charging strategies should be adapted to produce sufficient profit.

The Region Latin America & Caribbean

At the year 2001, the ratio between GDP and salaries was 2,428. That is: revenue should be 2,428 times the salaries paid to Communication Sector to balance the production expenses. It is, then, the minimum return a Provider should earn to survive; any value of the ratio greater than 2,428 will produce profit.

By the year 2006, the basic ratio keeps almost constant becoming 2,420, having assumed greater values during the period. The minimum productivity requested by the system is similar to that in 2001; the charging strategies may satisfactorily produce revenue that may secure profit.

The Region Middle East & North Africa

At the year 2001, the ratio between GDP and salaries was 2,246 That is: revenue should be 2,246 times the salaries paid to Communication Sector to balance the production expenses. It is, then, the minimum return a Provider should earn to survive; any value of the ratio greater than 2,246 will produce profit.

At the year 2006, the basic ratio moves up to 2,744, having gradually moved up during the period. The minimum productivity requested by the system is greater than in 2001; the charging strategies should produce revenue that not only satisfy basically this objective but should be greater.

8. Market behaviour

The consumer's utility function $f(Q_1, Q_2, \dots, Q_n)$ is the representation of particular commodities combination, among those possible, whose ranking can provide the maximum satisfaction. Maximisation of utility function, subject to income constraint $I = p_1Q_1 + p_2Q_2 + \dots + p_nQ_n$, suggests that the ratio of marginal utility for any pair of commodities must equal the ratio of relevant prices.

The demand function of a single consumer gives the quantity of a commodity the user will buy according to commodity price and to his income. The demand function is a straight line, negatively sloped, defined in the reference quadrant "Q" (quantity demanded of a commodity) and "p" (unit price of commodity demanded) whose intercepts are "p_{max}" (Y axis: maximum price producing no consumption) and "Q_{max}" (X axis: maximum consumption at zero price).

Fundamentally we may distinguish two main sectors in the market: business and residential.

In the first case the recourse to information (Internet) and communication (telephone) services represents an essential part of operating activity for Firms and Entities in different national economic sectors. So, as long as communication and information services have been expanding, the producers added up new expenses which derive from their additional intermediate consumption associated with the work process. Being included in the budget such expenses are recovered, as all others, from the selling price of products offered to market. The expenses are, then, subsidised and the demand function only shift, at constant slope, to account for increase in prices or increase in consumption.

Different is the case of private sector. Families are final consumers in the sense that they cannot have any chance to compensate the increase in ICT expenses as they have only to rely on their salary: the demand function shifts only when income dedicated to this consumption increases. So when mobile telephone and Internet facilities are added to traditional telephone as to change the level of purchasing two main consequences may be expected: either private consumers revise their utility priorities or they accept to spend additional amount of money rather than give up the service. Providers should then use adequate strategies to attract subscribers and to keep their market share.

The market demand function for commodities is obtained by summing the demand functions of individual consumers (or group of consumers). A consumer's demand function for Q_i depends upon the price of Q_i , the prices (p_j) of all other commodities and his income (Y_i):

$$D_i = D_i(p_1, p_2, p_3, p_4, \dots, p_n, Y_i)$$

9. Market revenue ¹

In Annex 2.3 unit revenue were calculated for fixed telephone and mobile telephone. Final results were used as to give a rough representation of intermediate consumption for Providers. In that case, unit revenue were associated with average GDP per employee as to for carry on the exercise. The same unit revenue are, now, used associated with the average Salary/employee which represents the reference to calculate the income per Residential user. The exercise shows how much of income might be absorbed whether a Residential users would make the same average consumption. Final results should be considered with.

A first logical selection must be done of data calculated: a consumption of about 5% of income seems acceptable, while a consumption greater than 25% is not. In the first case one salary is sufficient while in the second case a greater salary appears more reasonable (more than one salary for the same Residential for instance).

Regions	2002	2003	2004	2005
Europe	27,83%	26,89%	25,75%	24,81%
Asia/Pacific	22,45%	18,23%	14,97%	12,08%
Latin America	5,27%	5,54%	5,19%	4,74%
Africa/Mid East	19,10%	17,34%	14,30%	13,07%

In case of Europe, potential subscribers must be found among those Residential enjoying greater salary than the one assumed as a reference in the table. The same can be said for the Region Asia/Pacific and for Africa/Middle East. Experience suggests that final results obtained for Latin America might not correspond to a real situation.

Anyway, under the actual difficulty of obtaining appropriate data, the main objective of such analysis was not to get figures close to reality but rather to show the way of approaching consumers behaviour as to derive appropriate knowledge of market. By no doubt, whenever an economic study had to be carried on for a Firm (or for a country) it is expected that necessary data would be supplied in order to provide a valid support to the analysis.

Unit revenue per user show, in all cases, a decreasing trend over time. Within the three years considered above, Europe decreases by 3,76% per year, Asia/Pacific decreases by 18,66 % per year, Latin America decreases by 3,47% per year and Africa/Middle East reduces by 11,88% per year.

10. Economic efficiency and pricing

Efficient price for services is seen as the charge that meet the utility function of consumers and, in this way, meets a wanted social objective. From structural point of view efficient price

¹ www.itu.int/ITU-D/ict/statistics

implies that additional service provided should be charged at its marginal cost: in other words, efficient price ensures that customers pay the true economic value of products they buy.

Historically, under monopoly regulation, telecommunications operators decided to keep prices for network access below real cost; as a compensation, prices of other services were fixed above their real cost so that there was an economic subsidisation between the two. At the basis of such decision was the objective of encouraging low-income potential customers to join the network. Monopolist was as well discriminating users by imposing fixed rent for business customers greater than for Residential ones.

After liberalisation of Communication services the first step to take was to re-balance tariffs. It meant, in practice, to increase access prices and reduce prices for services that have traditionally subsidised low access prices. The objective, now, was to ensure that the price for each service could reflect its actual cost of provision in order to support free competition in the market.

Perfect competition in a market assumes that:

- Firms produce homogeneous commodities
- Consumers are identical for Providers
- There are no advantages/disadvantages associated with selling to a particular consumer
- Firms and consumers are numerous: each one have negligible control over prices
- Firms and consumers have perfect information about the prevailing price and current offer
- Entry into and exit from the market is free for Firms and consumers in the long run.

Unfortunately, in practice, perfect competition very rarely occurs. Telecommunications markets are very different from a hypothetical perfectly competitive market. In that:

- Firms produce multiple services
- Offer is differentiated by competitor (packaging, different pricing plans etc)
- Market share may not be negligible (dominant Provider)
- Customers widely vary demand and usage characteristics
- Economies of scale are prevailing

This means that, even under market competition, a number of Firms may not follow the simple pricing rules based on perfect competition model.

11. The residential consumers: describing behaviour

Residential consumers desire to purchase a combination of services from which they derive the highest level of satisfaction. Their problem is, then, to maximise their utility. However their income is limited and they are unable to purchase great amounts of commodities.

In mathematical terms, the maximisation of utility subject to budget constraints gives a special behaviour by which services to consume are ranked as a function of increasing prices. Users can revise their priorities as a function of changes in price of one or more commodities and/or of a change in their income.

Generalising the case to “n” commodities (not all complements to each other) and following still the mathematical approach, the utility function can be represented by:

$$U = f(Q_1, Q_2, Q_3, \dots, Q_n)$$

And the budget constraint is given by:

$$Y = \sum p_i \cdot Q_i$$

The maximisation of utility subject to budget constraint is given by maximising the following function:

$$M = f(Q_1, Q_2, Q_3, \dots, Q_n) + \lambda(Y - \sum p_i \cdot Q_i)$$

Taking partial derivatives (into the variables Q_i and λ) equal to zero provides $(n + 1)$ equations whose solution gives, per couple of commodities:

$$dQ_i/dQ_j = p_i/p_j$$

The general rule deriving is that the rate of substitution of commodity i for commodity j equals the price ratio p_j/p_i of commodities and still deals with their ranking.

12. Price discrimination

Price discrimination is feasible only if buyers are unable to purchase the product at a given price and resell it at greater price. Otherwise a service might be bought in a low-price market and resold in a high-price market at a profit, thereby producing equalisation of price in all market. The resale of commodities (electricity, gas and water) requires physical connection between the facilities of producer and consumer: but while it was difficult in the past (only fixed telephone), to day is facilitated by the existence of mobile telephone devices.

In a competitive environment consumers differ with respect to their ranking of products and to their income; Firms may, then, choose where to locate their final product and how much to charge each consumer. And, since Firms have knowledge about the distribution of consumers tastes, products may be offered that appeal to different market segments.

Tariffs are, then, fixed accordingly. It may even happen that high-income consumers are attracted by low-price products designed for low-income consumers. Many solutions are, in this case, opened to Provider: either to reduce charges of high-price products, or to reduce quality of low-price products or make a combination of the two.

Price discrimination is, further, to sell commodities (services) to different groups at different prices. Including or excluding the payment of fixed cost may, in this case, affect the surplus of consumers provided that they are tempted to use greater quantity of commodities in absence

of a fixed charge and, vice versa, do not arrive to limit consumption in presence of a fixed charge.